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(56) Documents cited
GB 2195808 A FR 002592514 A1

(58) Field of search
UK CL (Edition K) G5G G16 G4
INT CL^5 G09B
Online databases: WPI

(54) **Endoscopy training apparatus**

(57) A dummy endoscope has an insertion tube 2 which is received within a duct in a fixture 17 having sensor means 18 for sensing manipulative (ie, longitudinal and rotational) movement of the endoscope within the fixture. A simulated image of an endoscopic procedure is produced on a monitor 16 by a computer 15 which responds to outputs of the sensor means and to actuation of the endoscope controls 5, 8. The fixture 17 is provided with tactile means 19 which provide tactile feedback to the user under the control of the computer 15.

The tactile means 19 is variable so as to simulate the tactile response experienced using the endoscope when manipulated in like manner during anatomical endoscopic procedure.

The apparatus is suitable for training users of medical endoscopes.

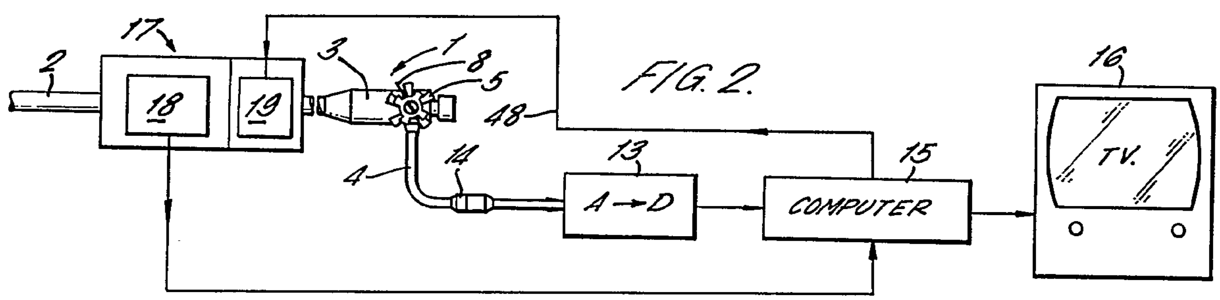

FIG. 2

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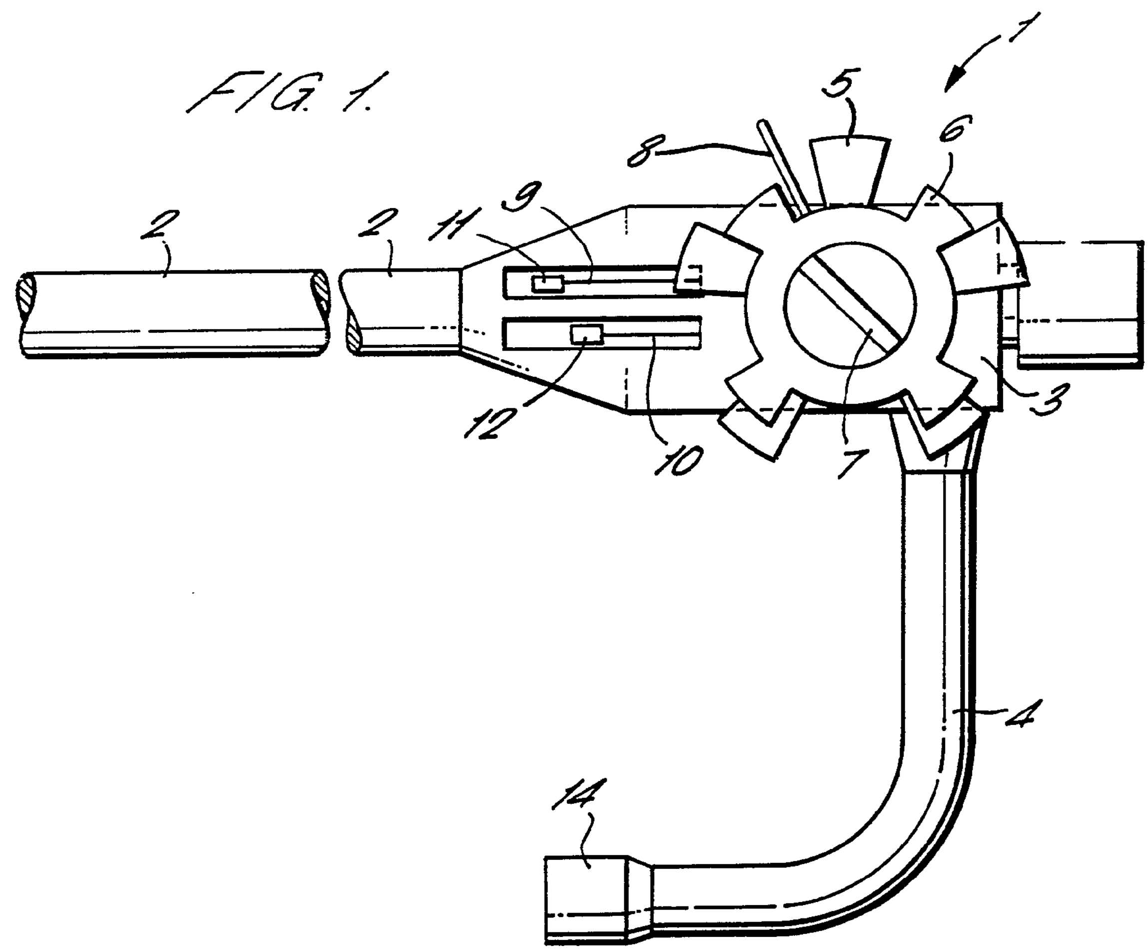
FIG. 1.



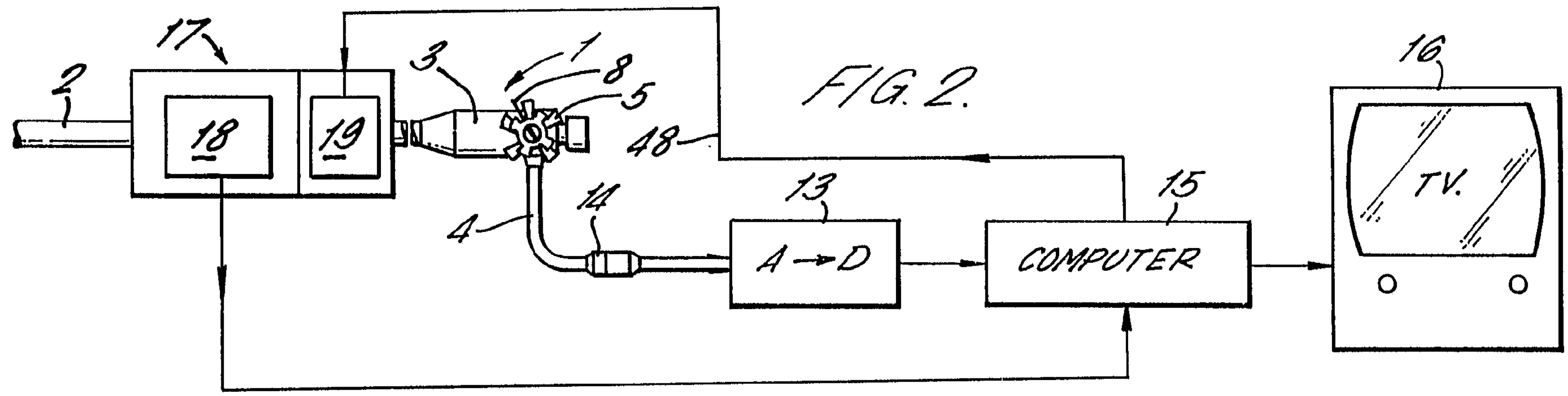


FIG. 2.

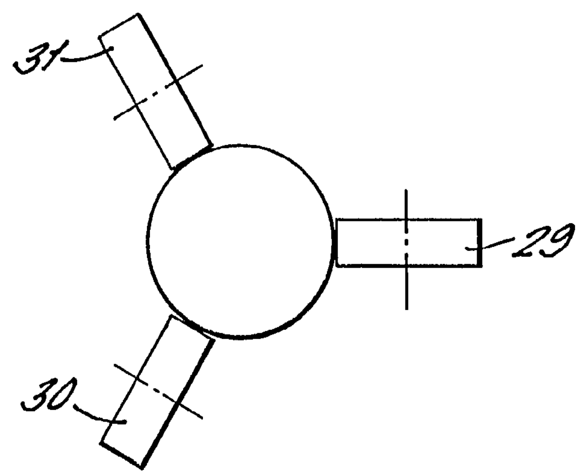
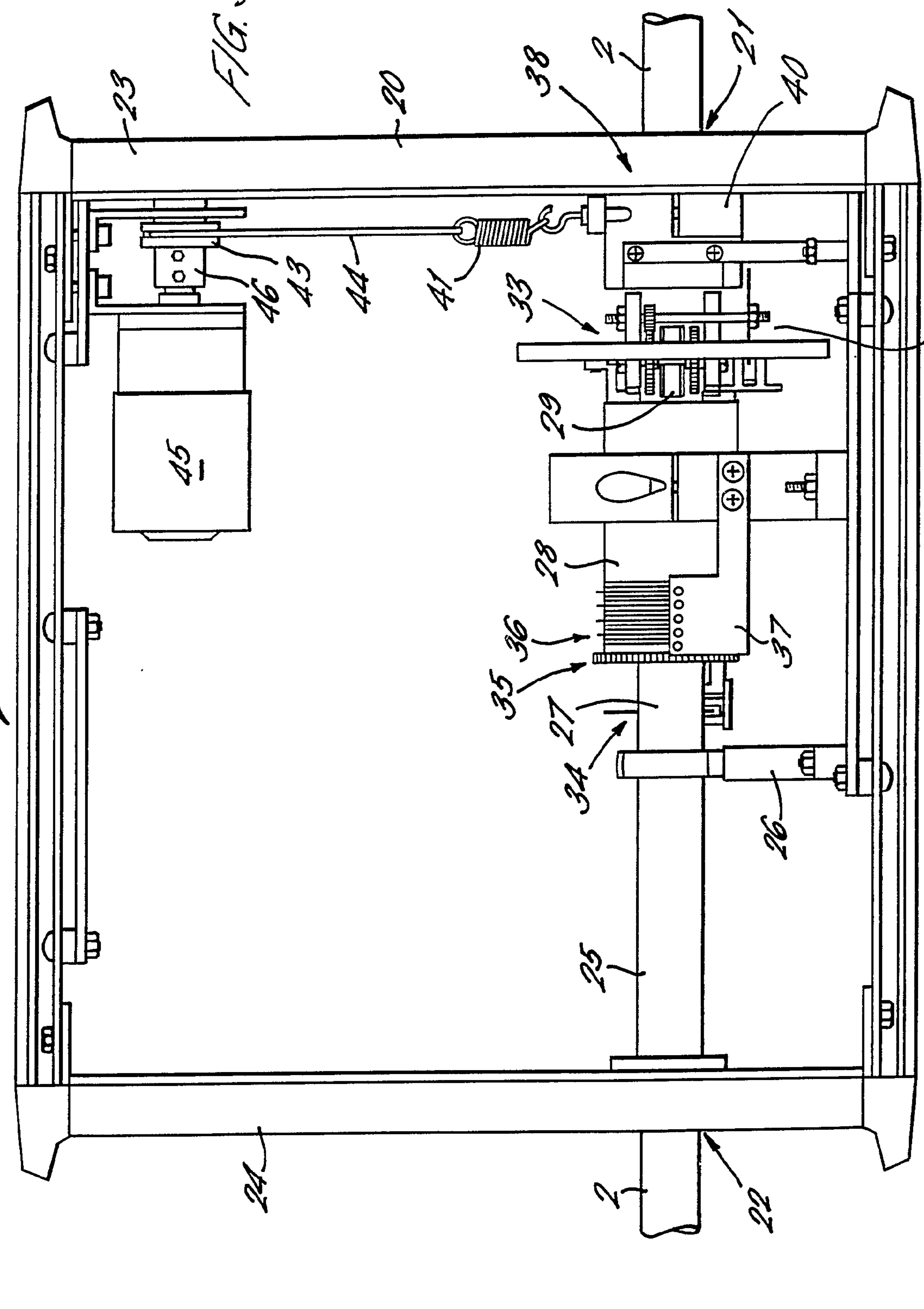


FIG. 6.

FIG. 3.



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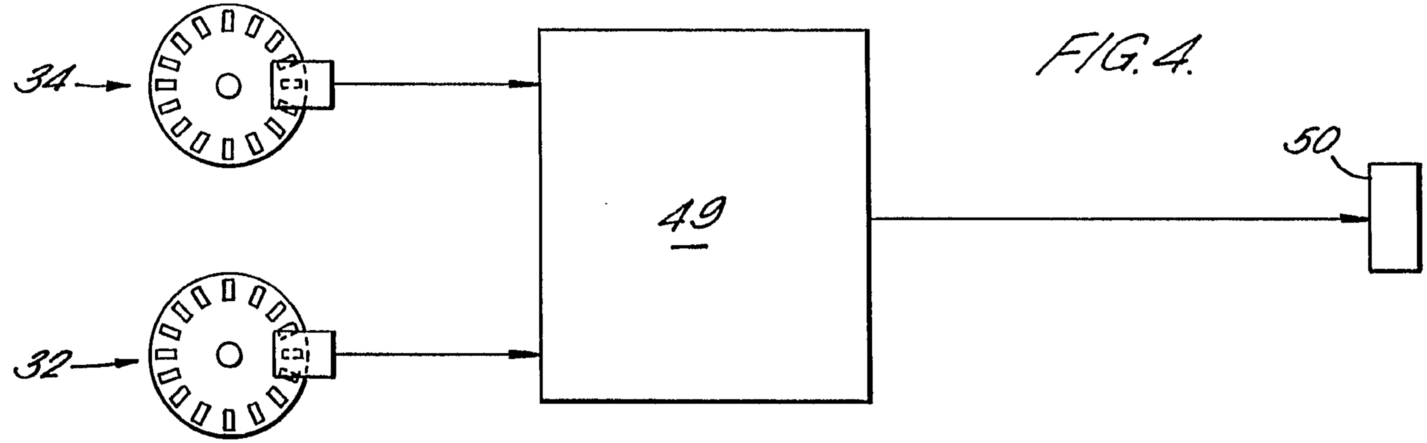

FIG. 4.

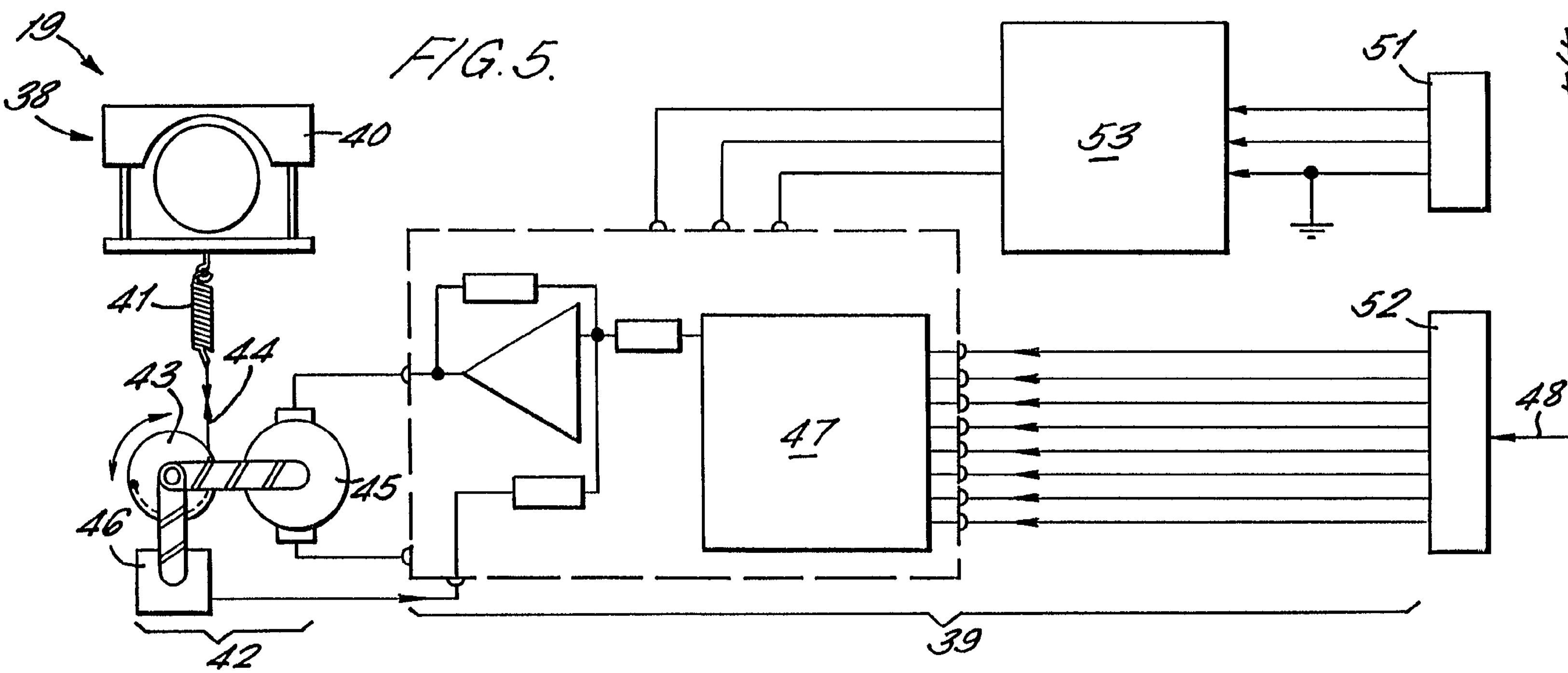

FIG. 5.

"IMPROVEMENTS IN ENDOSCOPY TRAINING APPARATUS"

This invention relates to apparatus for use in training an operator in the use of a medical endoscopic system.

The use of medical endoscope systems using flexible endoscopes is well-known and widely recognised as a very valuable diagnostic technique that enables medical staff to view directly any internal areas of the body that may be accessed via existing orifices to enable detection of the cause of a patient's symptoms.

The use of flexible endoscopes in the examination of various body cavities including the respiratory tract, upper and lower gastrointestinal tract, biliary tract and urethral tract requires a high degree of skill. Most notably, colonoscopy and duodenoscopy are recognised as requiring the highest level of operator skill to successfully achieve the objective of the clinical procedure.

In a typical endoscope most of the length of the insertion tube is covered in a firm plastic coating which is sufficiently flexible to follow the centre line of a colon or other tubular cavity but does not move otherwise. The last three inches or so of the insertion tube are however more flexible and the movement of this tip portion is controlled by wires which when pulled by means of controls bend the tip into an arcuate shape. Typically there are two sets of control wires arranged to give motion in orthogonal directions. The control wires are typically controlled by rotary control wheels which can be thumb operated. The use of the endoscope therefore involves simultaneous control of the two control wheels to change direction of the tip together with forward, backward or rotational

movement of the whole insertion tube and manipulation of other control buttons. The operator has a restricted visual field of view on which to base decisions about how to move the controls.

Teaching of these techniques by using anatomical models is preferred over training "on patient" as inappropriate technique or movement of the endoscope may result in patient trauma or even injury.

An already significant but growing number of endoscopies are now performed either with video endoscopes rather than fiberoptic endoscopes, or by fiberoptic endoscopes attached to a closed circuit television system, thus the endoscopic image is relayed to a television screen rather than being observed directly at the eyepiece of the instrument. To simulate such endoscope systems in a teaching environment would entail the use of expensive equipment that is unlikely to be dedicated to the training task and so if damaged would bring about inconvenience for both the user and any patients who were then unable to be examined because of non-availability of instrumentation.

According to the present invention there is disclosed apparatus for use in training an operator in the use of an endoscope system comprising a dummy endoscope having an insertion tube, a fixture defining a duct receiving in use the insertion tube, sensor means responsive to manipulation of the dummy endoscope to produce signals representative of longitudinal and rotational movement of the insertion tube relative to the fixture, and simulation means responsive to the signals to generate an operator viewable image simulating the image which would be viewable using the endoscope system when manipulated in like manner during an endoscopic procedure wherein

the simulating means further comprises tactile means operable between the fixture and the insertion tube so as to provide corresponding tactile feedback to the operator.

Preferably the tactile means comprises brake means operable to resist relative movement between the insertion tube and the fixture to an extent which is variable so as to simulate the tactile response experienced using the endoscope system when manipulated in like manner during an endoscopic procedure.

The operator may thereby gain experience as to how the endoscope would feel when manipulated in a particular way during a particular endoscopic procedure and can gain experience at co-ordinating visual and tactile information during the simulation.

Conveniently the brake means comprises at least one brake shoe and variable biassing means operable to bias the shoe into contact with the insertion tube.

In a preferred embodiment the biassing means comprises a spring and a motor operable to extend the spring to a variable extent.

Preferably the sensor means comprises a roller maintained in contact with the insertion tube when inserted within the fixture and arranged such that longitudinal movement of the insertion tube rotates the roller and means sensing rotation of the roller so as to produce a signal representative of longitudinal movement of the insertion tube relative to the fixture.

Conveniently the roller is connected to a rotor which is rotatable in unison with the insertion tube and further comprising means sensing rotation of the rotor relative to the fixture so as to produce signals representative of rotational movement of the insertion tube relative to the fixture.

Preferably the dummy endoscope includes one or more actuators corresponding to those actuators which are manipulatable in the endoscope system to be simulated and wherein the sensor means includes means producing signals responsive to movement of such actuators on the dummy endoscope.

Such a dummy endoscope may be fitted with a plurality of potentiometers, transducers or other motion indicators, the signals from which are then transferred to a small computer via analogue-to-digital converters, the digital signals then being processed by the computer to give a real time simulated endoscopic image on the screen of a suitable television monitor. The monitor may be driven by digital output from the computer or may be a conventional television receiver where a suitable video signal is generated by intermediate circuitry. The display may be incorporated into the dummy endoscope for viewing through the eyepiece if required. The processing programme is conveniently based on a three-dimensional computer model of the appropriate organ and endoscope, the programme reading the instantaneous position of the motion indicators to determine the simulated position of the endoscope tip within the organ, and using this viewpoint, drawing the appropriate view.

The model of the endoscope moving within the organ may be based on three coordinate systems, identified as the absolute, scope and tip systems defined as follows. The absolute system is the frame of reference in which the organ model is defined. Where the organ for example is a colon a simple model would comprise a curved cylindrical tube having spaced hoops on the inside surface of the tube representing bands of muscle. The origin of the scope system is referenced to the position of the

insertion tube at the interface between the main part of the insertion tube and distal bending section. The origin of the tip system is referenced to the tip of the distal bending section and therefore follows the position of the distal viewing lens of the endoscope as the up, down, left and right angulation controls are operated. Changes in the signals from the motion indicators are processed to update the relative position of the co-ordinate systems and it is a relatively straightforward computation to derive the relative position of the modelled features of the colon walls and the viewing lens. A two dimensional representation of the model as seen from the viewing lens is then calculated by conventional mapping methods.

As with all computer-based systems, there is a trade-off between the amount of data to be processed and the computation time. In this application the speed of response is more important than absolute realism of the computer-generated image, so in order for the screen image to be updated in "real time", the simulated view has to be kept simple, with only major "landmarks" being incorporated in the model. The choice of computer animation and modelling techniques will therefore depend upon the computing power available and the speed of response selected.

A non-exhaustive list of the parameters that may be included in such a simulator is: endoscope linear motion; endoscope rotary motion; up, down, left and right scope tip angulation; forceps raiser bridge angulation; linear and rotary motion of a range of endoscopic accessories such as snares, forceps, cannulae, papillotomy knives, biliary stents and the like; opening and closing motion of snares, forceps, papillotomy knives and the like.

An advantage of such a computer-based system is

that small low cost computers are readily available and thus a relatively inexpensive endoscopic training apparatus that simulates the image from an endoscopic video system can be assembled at a cost lower than that of the full endoscope system.

Although it is envisaged that the main area of use of this invention will be for aiding teaching of the more complex endoscopic techniques, such as colonoscopy and duodenoscopy, with different processing software, it is possible for any endoscopic technique to be simulated. Preferably the insertion tube is made substantially equal in length to that of the real endoscope system being simulated.

A specific embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:-

Figure 1 is a plan view of a dummy endoscope;

Figure 2 is a schematic view of apparatus including the dummy endoscope of Figure 1;

Figure 3 is a plan view of a fixture of the apparatus of Figure 2 and defining a duct through which the dummy endoscope of Figure 1 extends;

Figure 4 is a schematic diagram showing the connection of electronic elements of the apparatus;

Figure 5 is a further schematic diagram showing the control of a tactile feedback device; and

Figure 6 is a schematic axial view of the insertion tube illustrating the relative disposition of contact rollers within the fixture.

In Figure 1 a dummy endoscope 1 comprises an insertion tube 2 of the length appropriate to the procedure being simulated and connected to a control section 3. An umbilical cord 4 is connected to the control section 3 so as to appear identical to the umbilical cord of a real endoscope system but in this

instance containing electrical cables.

Mounted on the control section 3 are dummy angulation controls comprising the up/down control wheel 5, left/right control wheel 6 and the fixed/free brake controls 7 and 8. The control wheels 5 and 6 and the brake controls 7 and 8 correspond to the controls found on a typical real endoscope for use in controllably flexing a distal end portion of the insertion tube. In the dummy endoscope 1 however the insertion tube 2 is non-flexible in response to movement of the control wheels 5 to 8.

The control wheels 5 and 6 are connected by cables 9 and 10 to potentiometers 11 and 12 respectively such that the resistance of the respective potentiometers is dependent upon the position of the control wheels.

As shown schematically in Figure 2 the dummy endoscope is connected to an analogue-to-digital converter 13 by means of the umbilical cord 4 and multiway connector 14. The output of the analogue-to-digital converter 13 is connected to a computer 15 incorporating a mathematical model of the endoscope system and a graphics generating software package adapted for simulating the required anatomical cavity encountered in the endoscopic procedure to be simulated. The output of the computer 15 is connected to a television display monitor 16.

As indicated schematically at Figure 2 the insertion tube is received in a fixture 17 which defines a duct (not shown in Figure 2) within which the insertion tube is longitudinally and rotationally movable relative to the fixture. The fixture 17 incorporates sensor means 18 responsive to manipulation of the dummy endoscope 1 to produce

signals representative of longitudinal and rotational movement of the insertion tube relative to the fixture. These signals are connected to the computer 15 and provide additional input data to the mathematical model of the endoscope system.

The fixture 17 also incorporates tactile means 19 receiving control signals from the computer 15 operable between the fixture and the insertion tube 2 so as to provide tactile feedback to the operator corresponding to the progress of the modelled endoscope procedure as displayed visually on the monitor 16.

The fixture 17 is shown in greater detail in Figure 3 where it is seen to comprise a housing 20 through which the insertion tube extends via apertures 21 and 22 formed in opposite front and rear walls 23 and 24 of the housing 20 respectively.

A guide tube 25 is mounted in alignment with the apertures 21 and 22 and projects from the rear wall 24 to a free end 27 approximately midway between the front and rear walls 23 and 24. A support bracket 26 is provided to support the free end 27 of the guide tube 25.

The apertures 21, 22 and the guide tube 25 together define a duct within which the insertion tube 2 is slidably received.

A tubular rotor assembly 28 is mounted on the free end 27 so as to be rotatable about the axis defined by the duct whilst being constrained against axial movement relative to the guide tube 25. Contact between the rotor assembly 28 and the endoscope insertion tube 2 is made by means of circumferentially spaced rollers 29, 30 and 31 illustrated schematically in Figure 6. Roller 29 is seen in Figure 3 and constitutes a pick-up roller which drives a first optical shaft encoder 32 via a

gear train 33. The remaining rollers 30 and 31 are spring biassed into contact with the insertion tube 2 such that good frictional contact is made between the pick-up roller 29 and the tube.

Rotation of the rotor assembly 28 relative to the guide tube 25 is transmitted to a second optical shaft encoder 34 via a further gear train 35. An electrical slip ring connector 36 is provided for the conduction of signals from the shaft encoder 32 to a pick-up arm 37 which is fixedly connected to the housing 20.

A frictional brake 38 is also included in the housing 20 as shown in Figure 3 and is connected to a brake control unit 39 as shown schematically in Figure 5. The frictional brake 38 includes a brake shoe 40 which is biassed radially into contact with the insertion tube 2 by means of a spring 41 which is held in tension to an extent which is variable by means of a tension control assembly 42. The tension control assembly 42 consists of a drum 43 on which is wound a cable 44 connected to the spring 41, the drum 43 being rotatably adjusted in position by means of a motor 45 driven by the brake control unit 39 such that by winding or unwinding the cable the extension of the spring is variable. Positional feedback of the position of the drum 43 is provided to the brake control unit 39 from an angular position sensing transducer 46.

The brake control unit 39 includes a digital to analogue converter 47 receiving digital signals from a data bus 48 connected to the computer 15. The brake control unit 39 is powered by a power supply unit 53 as shown schematically in Figure 5.

The first and second shaft encoders 32 and 34 are connected to a displacement processing electronic circuit 49 as shown schematically in Figure 4 which

converts the outputs of the respective encoders into signals representative of longitudinal and rotational movement of the insertion tube relative to the fixture 17 which are transmitted via an output socket 50 to the computer 15 in a format of the type conventionally used for coding the tracker ball position of a computer mouse device. The fixture 17 is also provided with further sockets 51 and 52 for power supply connections and connection to the data bus 48 respectively.

The fixture 17 also includes an optical sensor (not shown) positioned adjacent to the aperture 21 and arranged to sense the presence of the insertion tube.

In use the insertion tube is inserted into the aperture 21 and this generates from the sensor a signal to the computer that insertion has taken place. As the insertion tube is advanced further into the duct it is engaged by the rollers 29, 30 and 31 and longitudinal movement of the insertion tube is measured by the first shaft encoder 32. The computer 15 is operated to run a programme embodying the mathematical model of the endoscopic procedure which is under simulation and a visual display is output to the monitor 16. Rotational movement of the insertion tube 2 results in the rollers 29, 30 and 31 rotating in unison with the insertion tube and taking with them the entire rotor assembly 28. This rotation is sensed by the second shaft encoder 34 which provides an output to the computer 15.

Longitudinal and rotational motion of the insertion tube 2 relative to the fixture 17 is thereby input to the mathematical model being run in the computer 15 and the image viewed in the monitor 16 is updated appropriately. The model generates instructions to the tactile means 19 in order to

provide appropriate tactile feedback to the operator who is manipulating the dummy endoscope 1. Such signals are delivered via the data bus 48 to induce adjustments of the tension control assembly 42 thereby applying or releasing the brake 38 in a controlled manner. Application of the brake 38 to increase friction will present a resistance to both longitudinal and rotational motion of the insertion tube 2 to the operator who is manually manipulating the dummy endoscope 1. Releasing the brake 38 will free the insertion tube 2. Intermediate settings of the brake 38 allow the tactile response to be continuously adjustable.

The variable brake action thereby provided enables the resistance to motion encountered when using a real endoscope to be accurately simulated. Rotation of the insertion tube 2 is unlimited i.e. rotation of more than 360^{o} can be facilitated because of the slip ring connector 36 which removes the need for flexible connectors between the rotor assembly 28 and the fixture 17.

The embodiment described above can optionally be enhanced to include an operating channel within the dummy endoscope, movement through which can be monitored by a further linear potentiometer; a simulated forceps raiser bridge mechanism, movement of which could be monitored by a further linear or rotary potentiometer; further potentiometers to monitor the condition of a simulated endoscopic accessory's handle position (open or closed) and other aspects of an endoscopy system's operation. Additional hardware extending from the real endoscope tip can correspondingly be modelled so as to appear in the simulated image.

The dummy endoscope may also emulate the controls which in a real endoscope provide delivery

of liquid, gas or suction through the insertion tube for flushing, inflating or evacuating a body cavity. These control functions may be emulated by providing dummy control buttons actuating switches sensed by the computer.

Alternative embodiments of the invention are envisaged with different movement/positional monitoring devices being used in place of or in addition to potentiometers.

The image produced may be a simple monochrome line drawing or, by using more powerful computers or at the expense of processing time, more realistic images could be produced with shading and/or greater detail. To achieve "real-time" processing with a small computer of the PC type, the system will conveniently work with monochrome images, but with the use of more powerful computers, colour images could be produced.

CLAIMS:

1. Apparatus for use in training an operator in the use of an endoscope system comprising a dummy endoscope having an insertion tube, a fixture defining a duct receiving in use the insertion tube, sensor means responsive to manipulation of the dummy endoscope to produce signals representative of longitudinal and rotational movement of the insertion tube relative to the fixture, and simulation means responsive to the signals to generate an operator viewable image simulating the image which would be viewable using the endoscope system when manipulated in like manner during an endoscopic procedure wherein the simulating means further comprises tactile means operable between the fixture and the insertion tube so as to provide corresponding tactile feedback to the operator.

2. Apparatus as claimed in claim 1 wherein the tactile means comprises brake means operable to resist relative movement between the insertion tube and the fixture to an extent which is variable so as to simulate the tactile response experienced using the endoscope system when manipulated in like manner during an endoscopic procedure.

3. Apparatus as claimed in claim 2 wherein the brake means comprises at least one brake shoe and variable biassing means operable to bias the shoe into contact with the insertion tube.

4. Apparatus as claimed in claim 3 wherein the biassing means comprises a spring and a motor operable to extend the spring to a variable extent.

5. Apparatus as claimed in any preceding claim wherein the sensor means comprises a roller maintained in contact with the insertion tube when inserted within the fixture and arranged such that longitudinal movement of the insertion tube rotates the roller and means sensing rotation of the roller so as to produce a signal representative of longitudinal movement of the insertion tube relative to the fixture.

6. Apparatus as claimed in claim 5 wherein the roller is connected to a rotor which is rotatable in unison with the insertion tube and further comprising means sensing rotation of the rotor relative to the fixture so as to produce signals representative of rotational movement of the insertion tube relative to the fixture.

7. Apparatus as claimed in any preceding claim wherein the dummy endoscope includes one or more actuators corresponding to those actuators which are manipulatable in the endoscope system to be simulated and wherein the sensor means includes means producing signals responsive to movement of such actuators on the dummy endoscope.

8. Apparatus as claimed in any preceding claim wherein the insertion tube is substantially equal in length to that of the endoscope system being simulated.

9. Apparatus for use in training an operator in the use of a medical endoscope system substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9102822.5

Relevant Technical fields

(i) UK Cl (Edition K) G5G (G4, G16)

(ii) Int Cl (Edition 5) G09B

Search Examiner
CASLING

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search
11 MARCH 1992

Documents considered relevant following a search in respect of claims 1 TO 9

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2195808 A (DAYKIN)	Claim 1 at least
A	FR 2592514 A1 (BEER-GABEL)	Claim 1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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